

## **Inquiry Lab: Exploring the Spectrum**

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### **9<sup>th</sup> Grade Earth Systems**

#### **Utah State Curriculum connections:**

Standard I: Students will understand the scientific evidence that supports theories that explain how the universe and solar system developed.

Objective 1: Describe the big bang theory and evidence supporting it.

#### **Intended Learning Outcomes:**

1. Use Science Process and Thinking Skills
  - a. Observe objects, events and patterns and record both qualitative and quantitative information.
  - b. Use comparisons to help understand observations and phenomena.
4. Communicate Effectively Using Science Language and Reasoning
  - a. Provide relevant data to support their inferences and conclusions

**Time Required:** Two 50 minute class periods.

#### **Inquiry:**

1. What kind of observations and inferences can be made by observing the spectrum of different light sources? (Observations – Part A)
2. Can you infer relative motions based on the Doppler Effect? (Confirmation – Part B)
3. What can be inferred from the spectral analysis of distant galaxies? (Guided Inquiry – Parts C and D)

**Background for Teachers:** Students need to understand the Doppler Effect. This was covered in the pervious lesson plan. Through experimentation, observation, and effective teacher questioning, students should become aware of the relationship between what scientists observe and the theories that are developed from these observations. This activity should help students accomplish the following: 1) understand that light sources give off spectrums and spectral lines, 2) make connections between personal observations and the spectral lines found in star light, 3) understand the Doppler Effect and that red shifted spectral lines indicate that a star is moving away from the observer, and 4) apply these observations as evidence for the big bang theory.

The Doppler Effect applies to all wave phenomena (water waves, sound waves, or light rays). In the case of light, the effect is difficult to demonstrate without using sophisticated instrumentation, because of the very high speed with which light moves. Therefore, while light is the wave of interest to astronomers, this activity will focus primarily on simulations to demonstrate the Doppler Effect and red shift. Once students understand these principles, they will interpret some astronomical data.

When the astronomer, Edwin Hubble, noticed the many red shifts compared to the very few blue shifts in stars and galaxies, he realized that the universe is expanding. Scientists can now point to what the universe must have looked like in the past if we are currently watching it expand. If the universe is truly expanding, then that means at some point in time, all of the matter must have been together. The explosion known as the **big bang** is generally referred to as the beginning of the universe. At a certain

time in the past, all matter and energy was found in one spot. Over 13 billion years ago, the big bang sent that matter and energy outward, and the universe began.

## Procedure:

### Day One: Observations

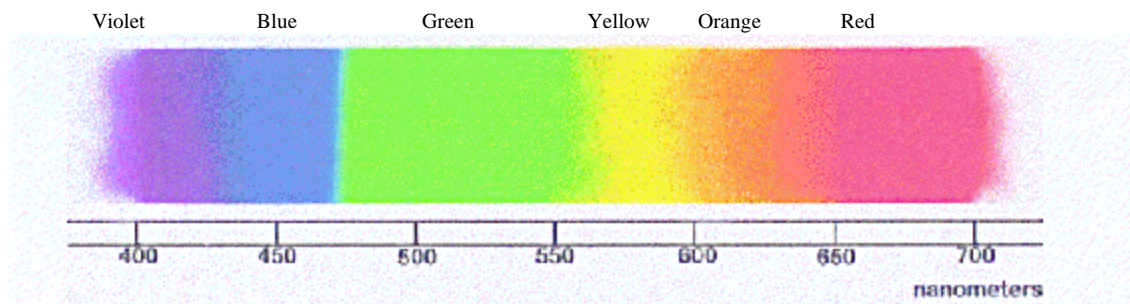
Materials needed: Spectroscope  
Worksheet: Spectrum Observations

Working in groups, students should record detailed observations made as they look at various light sources through a spectroscope. They should be encouraged to observe spectrums, spectral lines and the numbers (units in nanometers) on the spectroscopes that correspond to colors of the spectrum. Light sources can be fluorescent light found in overhead tube lighting, incandescent light found in an overhead projector light, sun light, black light, light from a flame (Bunsen burner), and other various light sources that maybe available. Have them complete Part A – Spectrum Observations on the Student Handout.

Teacher-lead Discussion: Discuss student observations, make connections to scientific concepts, and then infer meaning. As a class, spend some time discussing student observations of spectrums, spectral lines and the nanometer units associated with each colors of the spectrum.

1. Draw out from students the following points:

- Blue light and red light are both just light, or energy, but the blue light has a higher frequency, or shorter wavelength, than the red light.
- The wavelengths get successively longer when moving from left to right in the spectroscope. Visible light runs from about 400 to 700 nanometers.



- At 600 nanometers, what color would you expect to see? At 450? At 650?

### Day Two – Parts B-D

**Part B – Spectral Line Analysis:** Working in groups, have students complete Part B – Spectral Line Analysis in the student handouts focusing on the Red Shift and inferences that can be made.

Have each group present their interpretation of the data. Use formative assessment techniques to have students reach the correct analysis that B is moving away from the observer because wavelength is longer and that C is toward the observer and is moving faster than B.

Introduce the terms red-shifted and blue-shifted AFTER the student interpretation of their data.

**Part C – Distant Galaxy Spectrums:** Working in groups of three to four, assign Part C – Distant Galaxy Spectrums. After the students have had a chance to complete their conclusions inferred from the

data, have each group present their conclusions and rationalizations. Using formative assessment techniques, have the class reach a consensus of:

- Distant galaxies are moving away from our galaxy
- The farther away the galaxy is, the faster it is moving away from us.

**Part D – The Big Inference:** Have each group present their conclusions and rationalizations. Using formative assessment techniques have the class reach a consensus that at one time all the galaxies in the universe must have been all together. Introduce the Big Bang theory and provide other supportive evidence for it (background microwave radiation).

Summarize with students:

- Technological developments have helped us formulate the Big Bang theory.
- This is the scientifically accepted theory of the origins of the universe because so much data has been collected that supports it.
- This theory could change in the light of new evidence.

Works Cited: <http://genesission.jpl.nasa.gov/educate/scimodule/Cosmogony.html>

(More information and additional astronomy activities can be found on this website).

Name \_\_\_\_\_

Period \_\_\_\_\_

Date \_\_\_\_\_

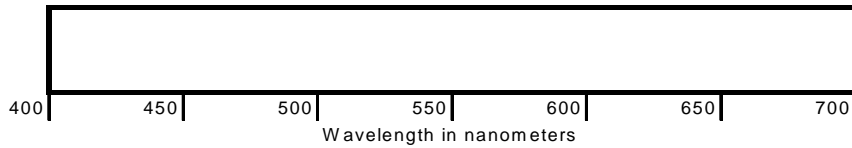
## Inquiry Lab: Exploring the Spectrum

### Student Handout

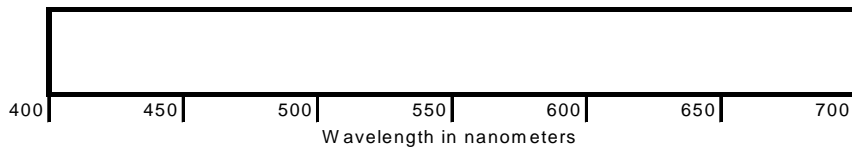
#### Part A – Spectrum Observations

You will be exploring light in much the same way as the scientist do. An important part of scientific understanding comes from making and recording careful observations. This will be an important part of your scientific discovery and information gathered will be used throughout this activity. Using a spectroscope, look at as many light sources as you can find. When doing a spectral analysis of a light source, try to be as close to the light source as possible or darken the room. This prevents “contamination” from other light sources. Be sure to carefully color in the exact spectrum you see above the corresponding numbers (wavelengths of the light waves). Start with looking at sunlight.

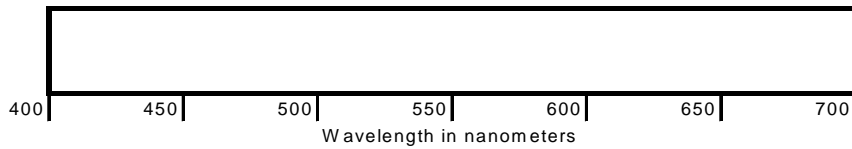
Light source: \_\_\_\_\_



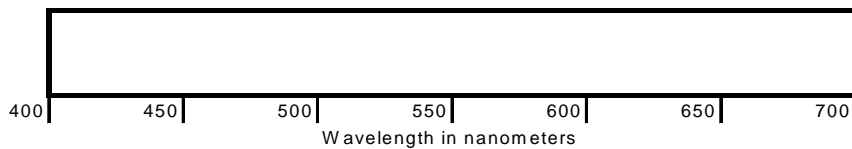
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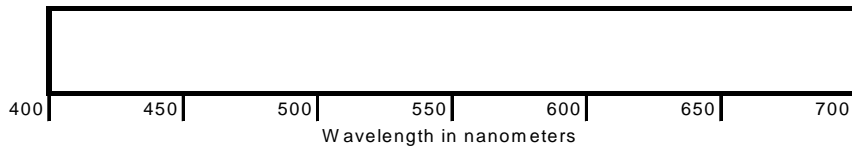
Light source: \_\_\_\_\_



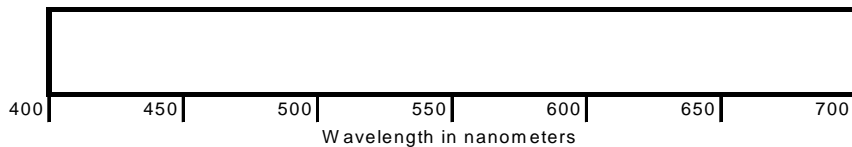
Light source: \_\_\_\_\_



Light source: \_\_\_\_\_



Light source: \_\_\_\_\_



Now that you have some scientific data to work with, start looking for patterns in your observations. Think about things like similarities, differences, and consistencies. Record five patterns observed.

1.

2.

3.

4.

5.

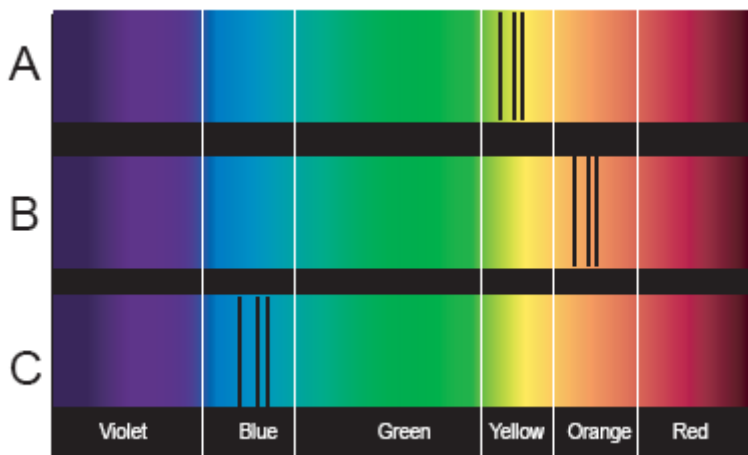
Interpret:

1. Why does sunlight show up as a “rainbow of colors” in your spectroscope?
2. Did you notice any changes in individual color intensity between the light sources? What does this mean?
3. Did you notice any dark lines or dark areas in the spectrum of any of the light sources? What does a dark line (or dark area) in a spectrum mean?

***Be prepared to share observations and patterns in a class discussion.***

## Part B - Spectral Line Analysis

Study the following.



Spectrums A, B and C are from identical stars within our galaxy. Spectrum **A** represents a possible spectrum of a star not moving toward or away from Earth. Spectrums **B** and **C** show stars in motion with respect to an observer on Earth. Compare the three spectrums and answer the following questions:

1. What is the approximate range in nanometers that the black lines fall in for A? for B? for C?
2. Which spectrum is that of a star moving toward Earth?
3. Which spectrum is that of a star moving away from Earth?
4. In comparison to A, which is moving faster, B or C? Using data, justify your answer.

## Part C - Distant Galaxy Spectrums

With the advent of new microwave detectors, hydrogen was found to emit 21.00 cm wavelengths of “light”. This wavelength of “light” belongs to the microwave region of the electromagnetic spectrum. Below are presented spectral data taken from stars in our own galaxy and of far-away galaxies. Each spectrum only shows information collected in the microwave (21.00 – 21.30 cm) region of the electromagnetic spectrum where the characteristic dark lines of hydrogen are found. The microwave “light” given off by hydrogen is shown as the two dark bands in each of the spectrums below. These spectrums have been redrawn from the actual spectra of hydrogen measured in a laboratory to enhance their clarity.

Galaxy	Wave length (cm)
Light-years away	21.00 21.10 21.20 21.30
Stars in the Milky Way	II
A few light-years	21.00 21.10 21.20 21.30
Ursa Major	II
1,000,000,000	21.00 21.10 21.20 21.30
Corona Borealis	II
1,400,000,000	21.00 21.10 21.20 21.30
Bootes	II
2,500,000,000	21.00 21.10 21.20 21.30
Hydra	II
3,960,000,000	21.00 21.10 21.20 21.30

1. Make a chart below that contains the name of each galaxy and the approximate wavelength reading for the hydrogen emission “dark bands” in that galaxy.
2. Based on your understanding of the Doppler Effect, what two things can you infer from these spectrums? Use the data to defend your conclusions.

## **Part D – The Big Inference**

Most galaxies are red-shifted, or moving away from us today. Let's rewind the clock of time. Using the information and data from this lab, what can be inferred about the origin of the universe?